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# APPLICATION FOR UNITED STATES PATENT

in the name of

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Of

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For

FABRIC WITH HEATED CIRCUIT PRINTED ON  
INTERMEDIATE FILM

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# FABRIC WITH HEATED CIRCUIT PRINTED ON INTERMEDIATE FILM

## TECHNICAL FIELD

This application claims benefit from U.S. Provisional Application No. 60/270,847, filed February 23, 2001. This application is also: a continuation-in-part of U.S. Application No. 09/\_\_\_\_\_, filed February 25, 2002, now pending, which is a continuation-in-part of U.S. Application No. 09/791,237, filed February 23, 2001, now pending, which is a continuation-in-part of U.S. Application No. 09/697,100, filed October 26, 2000, now pending, which is a continuation-in-part of U.S. Application No. 09/395,326, filed September 13, 1999, now U.S. Patent No. 6,160,246, issued December 12, 2000, which is a division of U.S. Application No. 09/296,375, filed April 22, 1999, now abandoned. This application is also: a continuation-in-part of U.S. Application No. 09/592,235, filed June 12, 2000, now pending; and a continuation-in-part of U.S. Application No. 09/703,089, filed October 31, 2000, now U.S. Patent No. 6,307,189, issued October 23, 2001, which is a division of U.S. Application No. 09/468,627, filed December 21, 1999, now U.S. Patent No. 6,215,111, issued April 10, 2001. This application is also: a continuation-in-part of U.S. Application No. 09/389,761, filed September 2, 1999, now pending, which is a division of U.S. Application No. 09/298,722, filed April 23, 1999, now U.S. Patent No. 6,111,233, issued August 29, 2000. The complete disclosures of all of the above-listed patents and patent applications are incorporated herein by reference.

This invention relates to flexible electric heating/warming elements suitable for use in fabric articles such as clothing and footwear, blankets, heating pads and home furnishings.

## BACKGROUND

It has been known to provide electrical heating /warming in flexible fabric articles such as clothing and blankets, including by incorporating elements of electrical heating/warming circuits directly into the fabric, by attaching elements of the electrical circuit to the fabric or to an intermediate substrate, or by inserting the electrical circuit, or elements thereof, between layers of fabric. It has also been known to provide an electrical heating/warming circuit secured between layers of fabric material, including for protection of the circuit. For example, Gross et al. U.S. 3,906,185 describes a heating circuit for footwear

printed on a layer of a plastic, e.g., polyethylene, and covered by a layer of plastic of same material. Gross et al. U.S. 4,021,640 describes a heating circuit for a glove printed on MYLAR<sup>®</sup> film and covered with plastic film for electrical insulation. Smith U.S. 3,657,519 describes a heated diving suit formed of stretchable electrically conductive material, e.g. neoprene rubber containing conductive particles of silver or carbon, disposed between waterproof, electrically insulating, stretchable coating layers, e.g., latex, polyurethane or butyl rubber. St. Cyr U.S. 2,210,618 describes a medical device in which wire-heating elements are disposed between layers of cambric and heavy silk. Zhao U.S. 5,302,807 describes a laminated heating pad with the heater formed of folded aluminum foil with an insulating coating on each surface disposed between a layer of cotton cloth and polyethylene film.

#### SUMMARY

According to the invention, an electric heating/warming element includes a water-resistant, vapor-permeable bladder within which extends an electrical heating/warming circuit that generates heat when attached to a source of electrical power.

Variations of this aspect of the invention can include one or more of the following features. The electric heating/warming element is adapted to be incorporated, e.g., into articles of clothing, such as jackets, pants, headgear, gloves, footwear, etc.; heating pads and blankets; sports equipments, such as uniforms, helmets, pads, skates and boots, stadium blankets, etc.; medical heating devices; textile home furnishings; etc. The electric heating/warming circuit includes a fabric body with a plurality of spaced apart electrical resistance heating elements incorporated into the fabric body, in the form of conductive yarn, extending generally between opposite edge regions of said fabric body, and electrical conductor elements extending generally along said opposite edge regions of said fabric body and adapted to connect said plurality of spaced apart electrical resistance heating elements to the source of electrical power. The electrical conductor elements are adapted for connecting said plurality of spaced-apart electrical resistance heating elements to a power source of alternating current. The electrical conductor elements are adapted for connecting said plurality of spaced-apart electrical resistance heating elements to a power source of direct current. The power source of direct current includes a battery. A series of at least three

electrical resistance heating elements of said plurality of electrical resistance heating elements are symmetrically spaced. A series of at least three electrical resistance heating elements of said plurality of electrical resistance heating elements are asymmetrically spaced. The fabric body includes a knitted body. The fabric body includes a reverse plaited circular  
5 knitted body. The fabric body includes a woven body.

Other variations of this aspect of the invention can include one or more of the following features. The bladder includes hydrophilic material and/or hydrophobic material. The bladder has a technical face formed by a stitch yarn and a technical back formed by a loop yarn. The bladder includes a first and a second layer, each of which provides an inner  
10 surface of the bladder, the electrical heating/warming circuit being attached to one of said inner surfaces. The electrical heating/warming circuit is printed upon one of the inner surfaces of the bladder. One of the first and second layers of the bladder includes a fabric layer having an inner surface and an outer surface, a barrier layer disposed at the inner surface of the fabric layer, the barrier layer having an inner surface and an outer surface, and  
15 the electrical heating/warming circuit in the form of a flexible film disposed upon the inner surface of the barrier layer. The electrical heating/warming circuit is disposed upon the outer surface of the barrier layer. The electrical heating/warming circuit comprises a die-cut, sheet-form metalized layer attached to one of a first and a second broad surface of a fabric body. The electric heating/warming element further includes a phase change component  
20 associated with the bladder, the component having a phase change material formulated to change phase in a temperature range of use of the heating/warming element, to cyclically absorb and release latent heat in a manner capable of conserving use of the electrical power source.

The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the  
25 invention will be apparent from the description and drawings.

### DESCRIPTION OF DRAWINGS

FIG 1 is a somewhat diagrammatic, perspective, end sectional view of a first embodiment a heating /warming element of the invention;

FIG. 2 is a somewhat diagrammatic end sectional view of another embodiment of a heating/warming element of the invention;

FIG. 3 is a similar view of still another embodiment of a heating/warming element of the invention;

5        FIG. 4 is a similar view of yet another embodiment of a heating/warming element of the invention; and

FIG. 5 is a similar view of another embodiment of a heating/warming element of the invention.

Like reference symbols in the various drawings indicate like elements.

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#### DETAILED DESCRIPTION

Referring to FIG. 1, an electric heating /warming element 10 of the invention consists of a bladder 12 formed of opposed layers 14, 16 of a suitable, water-resistant, vapor-permeable (i.e., breathable) polymeric material, e.g., comprising a hydrophobic porous material, such as poly tetra fluoro ethylene (PTFE), or comprising a non-porous hydrophilic material, such as polyurethane, with a heating/warming circuit 18 secured therewithin. The heating/warming circuit 18 is adapted to generate heating/warming when electrical power is applied, e.g. through electrical leads 19, 21.

Referring to FIG. 2, in a further embodiment, a heating/warming element 100 of the invention consists of a bladder 112 with a flexible heating/warming circuit 118 printed upon an inner surface 117 of one or both layers 114, 116 of suitable water-resistant, vapor-permeable polymeric material forming the bladder 112. For example, the printed circuit 118 may be formed as described in U.S. Patent No. 6,111,233; U.S. Application No. 09/389,761, filed September 2, 1999; U.S. Application No. 60/175,202, filed January 10, 2000; and U.S. Application No. 60/261,544, filed January 12, 2001, the complete disclosures of all of which are incorporated herein by reference. The electrical leads 119, 121 terminate, e.g., in a plug 122 for engagement in a wall outlet (not shown) for powering the electrical heating/warming element 100 by alternating current (AC) electrical power.

Referring next to FIG. 3, in a further embodiment, the heating warming element 200 of the invention consists of a bladder 212 formed of opposed layers 214, 216 of suitable water-resistant, vapor-permeable polymeric material. The bladder contains a

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heating/warming circuit 218 in the form of a fabric substrate 220 into which are incorporated conductive yarns 222. For example, the conductive yarns may be incorporated into the fabric body 220 as stitch yarns in a standard reverse plaiting circular knitting (terry knitting) process, e.g., as described in Knitting Technology, by David J. Spencer (Woodhead Publishing Limited, 2nd edition, 1996), the entire disclosure of which is incorporated herein by reference. Preferably, the heating/warming circuit 218 has the form of a parallel electrical circuit, with the conductive yarns 222 connected in parallel along opposite edge regions by conductive buses (not shown), or otherwise as described in U.S. Patent No. 6,160,246; U.S. Patent No. 6,215,111; U.S. Application No. 09/697,100, filed October 26, 2000; and U.S. Patent No. 6,307,189; the complete disclosures of all of which are incorporated herein by reference. The electrical leads 219, 221 terminate, e.g., in a plug 226 for engagement in an automobile cigarette lighter or other power outlet (not shown) for powering the electrical heating/warming element 200 by direct current (DC) electrical power from the automobile battery.

Referring to FIG. 4, in a further embodiment of the invention, a heating/warming element 300 consists of a bladder 312 formed of opposed layers 314, 316 of suitable water-resistant, vapor-permeable polymeric material. The bladder 218 contains a heating/warming circuit 318 in the form of a substrate 320, e.g., formed of fabric, scrim, etc., with the electrical circuit 318 formed of conductive yarns 322 attached upon one surface 324 (or both surfaces) of the substrate 320. For example, the conductive yarns 322 may be stitched, e.g., embroidery stitched, or otherwise fastened upon surface 324 of the substrate 320, such as described in U.S. Application No. 09/592,235, filed June 12, 2000, the complete disclosure of which is incorporated herein by reference. The electrical leads 319, 321 are connected, e.g., to the terminals 329, 331 of a battery 332 to power the electrical heating/warming circuit by DC power.

Referring to FIG. 5, in an alternative embodiment of a heating/warming element 400 of the invention, e.g., as described above with respect to FIGS. 3 and 4, the bladder 412 contains an electrical heating/warming circuit 418, and further contains a phase change component (indicated generally at 432), as described in U.S. Application No. 09/974,371, filed October 10, 2001; the complete disclosure of which is incorporated herein by reference. The phase change component may be a phase change material incorporated into the fabric

substrate 420 or may be affixed thereupon in any suitable manner. For example, a suitable phase change material may be microencapsulated in fibers forming or incorporated into the fabric substrate 420 and/or in fibers of conductive yarns, and/or in a coating or layer applied to the fibers and/or to the fabric substrate. Preferably, the phase change material is selected to  
5 absorb and release latent heat by changing phase within the temperature range typical for use of a personal textile electric heating/warming article 400, e.g., such as a heating blanket, a heating pad, an article of apparel, an article of home furnishings or the like, e.g. about 32°F to about 120°F. Suitable phase change materials may include, e.g., paraffin, glycol, and mixtures or blends of these or other materials, such as available commercially from Outlast,  
10 of Boulder, Colorado. However, the exact temperature range at which the change of phase may occur can be tailored to different predetermined temperatures by selection of the precise formulation of the phase change material.

A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and  
15 scope of the invention. Accordingly, other embodiments are within the scope of the following claims.

What is claimed is: